

California M E D I C I N E

OFFICIAL JOURNAL OF THE CALIFORNIA MEDICAL ASSOCIATION
©1958, by the California Medical Association

Volume 88

APRIL 1958

Number 4

The Treatment of Urinary Tract Calculi

WYLAND F. LEADBETTER, M.D., Boston

THERE IS A GREAT DEAL in the medical literature relative to factors in the initiation and development of urinary calculi, but it is safe to say that we do not yet know exactly how or why stones form. We recognize the relationship of excessive vitamin D administration, hyperparathyroidism, cystinuria and hyperuricuria to the development of calcium phosphate, cystine and uric acid stones and have assumed that such stones are to some extent the result of excessive concentration of these substances in the urine in association with inadequate volume of urine and urinary pH which favors the precipitation of crystals. Calculi developing in persons suddenly immobilized because of poliomyelitis, spinal injury or major trauma of any sort have been considered to result from high excretion of calcium salts released from the bony skeleton in association with inadequate volume of urine and high urinary pH.

There is no doubt that some stones form in the presence of obstruction and in the absence of demonstrable metabolic abnormalities by virtue, perhaps, of retention of crystals or crystalline masses which, in the absence of obstruction, would pass. Triple phosphate calculi occur frequently in the presence of urea-splitting infections, particularly when stasis is present as well.

We do not yet know much about oxalate metabolism and its relation to oxalate calculi. Nor do we know the specific factors responsible for the develop-

• From review of recent information relative to calculus formation in the kidney, the conclusion reached that we do not yet understand, despite much effort, the basic physicochemical mechanisms involved. Since this is so, it has seemed best to the author for the present to rely, in treating patients with renal stones, on simple therapeutic concepts, which, if carefully and conscientiously applied, produce good results. The concepts are the elimination of known causes such as parathyroid adenomas and obstructive lesions, elimination or at least treatment of infections, diminution of urinary components which form the basis of calculi by limiting the oral intake or absorption from the gastrointestinal tract and maintenance of a dilute urine of desired pH.

A plan for preoperative study is suggested to allow planned therapy. Indications for operative removal of calculi as well as some points of technique are discussed. It is emphasized that surgical removal of a calculus is but an incident in the care of patients with calculi and that treatment during the postoperative period and follow-up therapy is most important if success is to be achieved. Reports of cases to illustrate the application of these concepts are presented.

ment of Randall's plaques in or on the surface of renal pyramids which act as the point of origin of some calculi.

It seems unlikely that in this country vitamin A deficiency, a demonstrated cause of experimental calculi in animals, can play a major role in stone formation. Little is yet known of the role of colloids

Guest Speaker's Address: Presented before the Section on Urology at the 86th Annual Session of the California Medical Association, Los Angeles, April 28 to May 1, 1957.

in the process of stone formation. It has been assumed in the past that the physical state of dispersion of colloids may increase or decrease the ability of urine to hold the less soluble electrolytes in solution by adsorption. This may not be so.

Boyce, Garvey and Norfleet^{2,3} isolated the urinary biocolloids (their term for urinary colloids) and found that they consist of at least two mucoproteins. The largest single component is a carbohydrate-protein complex of high molecular weight. These mucoproteins were found to be greatly increased in the urine of some patients with calcium calculi. Two patients with hyperparathyroidism had the highest concentration of any patients they studied. Boyce suggested that the organic matrix of calculi may be a modified or activated form of the mucoproteins normally found in urine. His concept of stone formation is that the initial and essential phase is a condensation of mucopolysaccharides and mucoprotein molecules constituting a coagulum of uncalcified matrix which may vary in size from a few molecules to a mass large enough to fill a renal calyx or pelvis. Deposition of inorganic crystals is a secondary phenomenon usually occurring quite rapidly but sometimes requiring weeks to reach maximum density in large calculi. The deposition of crystals is governed by the principles of physical chemistry which controls the formation of crystals from complex solutions. The origin of calculus matrix remains unknown but the presence of similar or identical mucopolysaccharides in connective tissue and in bone matrix has been demonstrated. The stone matrix could be derived from bone matrix or connective tissue outside the urinary tract.

Baker and Connelly¹ expressed the opinion that the high molecular weight of mucoproteins in the urine makes it unreasonable to assume that their presence in the urine is the result of filtration throughout the glomerulus or of secretion or excretion by tubule cells. In experimental work they demonstrated alterations in the renal tubule connective tissue mucoprotein immediately preceding the development of calculi in rats. This was observed consistently with four different methods of producing experimental renal calculi. Needle biopsy specimens of both kidneys were obtained from a small number of patients with unilateral calculi, and bilateral alterations of the renal tubule connective tissue matrix or mucoprotein were observed. In rats renal calcification or stone formation occurred in the altered mucoprotein whether within the kidney (nephrocalcinosis) or the renal pelvis or urinary bladder. As a result of these and other observations it was their impression that formation of urinary calculi may not be a disease of urine but rather a systemic condition specifically involving the renal connective tissue matrix of both kidneys. Baker

expressed belief that evidence is accumulating that pathological calcification anywhere, including renal calculi, is a disease of connective tissue matrix and as such is essentially a collagen disease.

He went on to say that on the basis of this evidence—that is, altered connective tissue mucoprotein—he used “anti-inflammatory” drugs in treatment of animals with a known incidence of calculi and in a study of patients with recurrent stone, and there was an almost 50 per cent reduction of recurrence. Drugs used were acetylsalicylic acid, cortisone acetate, other corticosteroid hormones, phenylbutazone, and corticotropin. He cited the work of Snapper, Bendien and Polak,⁸ who showed that sodium salicylate inhibits precipitation of urinary colloids, and concluded that this concept of salicylate action is more tenable than the assumption of Prien and Walker^{5,6} that the administration of salicylate increases the solubility of calcium by virtue of increased glucuronide excretion in the urine.

Confirmation of these concepts is not yet at hand. Butts’ use of hyaluronidase to increase dispersion of urinary colloids has not been substantiated. Prien’s results from the use of acetylsalicylic or allied drugs to increase the solubility of calcium salts by the increased excretion of urinary glucuronides are open to question, although possibly their effectiveness may be found to be due to other mechanisms. The effect of estrogen and the role of citric acid as a calcium solubilizer has not yet been exploited.

We are left, therefore, with the necessity of dealing with factors that are to some extent under our control—metabolic disturbances, ingestion of calcium and phosphorus, urine volumes, urinary pH, obstructions and infections.

Since we are unable to single out potential stone-formers in the general population, we are not able to talk of the prevention of calculi except as we treat urinary tract infection, relieve obstruction and oversee the care of immobilized patients. We are, in general, confronted with the problem of preventing recurrence of calculi in persons relieved of calculi by spontaneous passage, cystoscopic instrumentation or operation. We also may be called upon to try to prevent further growth of calculi known to be present but for some reason not removed and, in addition, to try to dissolve them. So far, the methods available have been disappointing.

It is the purpose of this paper to show that effective therapy is possible without reference to colloids or acetylsalicylic acid.

It has been my observation that, in general, little is to be accomplished by attempts at dissolution or

limiting the growth of calculi. Most patients ultimately require surgical operation because of an acute situation due either to infection or obstruction or both, which not infrequently leads to operation at a time when removal of the stone is more difficult and necessary reparative procedures less likely to bring about a good anatomical and physiological result. It seems best to state that, barring exceptional situations resulting from age or serious disease, all calculi should be removed in appropriate fashion and at an appropriate time. The treatment of patients with renal or ureteral stones should be divided into three parts: (1) Preoperative examination, observation and treatment, (2) cystoscopic or operative removal and (3) postoperative care.

As a basis for postoperative therapy to prevent regrowth of calculi, complete examination and observation before operation is essential. It has become my practice to study all patients fully, regardless of the apparent situation. Sometimes this is impossible before operation because of an acute situation, but, if so, it should be done as soon as possible after operation because unexpected information may emerge from the study. The necessity for this has been impressed upon me in the course of treating patients with unrecognized hyperparathyroidism, hyperuricuria, cystinuria, and obstructive inflammatory situations which led to unnecessary sacrifice of kidneys, unnecessary disability, expense, and even death.

The plan for study of a patient consists of:

1. A careful history with emphasis on past and present urinary tract symptoms, injuries, operations, treatment of gastric or duodenal ulcer, dietary habits, usual daily fluid ingestion. Often this discloses valuable information which may permit a shrewd guess as to some factors responsible for calculi.

2. Physical examination, which is often unrewarding but should nevertheless be done carefully. Occasionally one may palpate a parathyroid nodule, or upon examination of the kidney areas, abdomen, genitalia or prostate, abnormalities may be noted which require investigation and may have causative relationship.

3. Examination of the urine. This should include a careful study of the sediment with attention to the crystalline content which may give a good lead as to the type of calculus. Culture and sensitivity studies provide a basis for antibiotic therapy before and after operation. The presence of urea splitting organisms should be known. A nitroprusside test for the presence of cystine should be routine. A Sulzko-witch test for calcium provides a rough idea of the calcium content in the urine.

4. X-ray studies are initiated with a kidney-ureter-bladder film and intravenous urograms, which may provide all necessary information, including the probable composition of calculi. However, in my opinion cystoscopic examination is essential. This should include estimation of residual urine, study for ureteral reflux, observation for bladder neck obstruction, and bilateral ureteral catheterization for collection of urine specimens for culture and estimation of pH. Good pyeloureterograms are essential. I have noted that ureterograms are often inadequate or often not done. An air pyelogram may be helpful in distinguishing nonopaque calculi from tumors of the renal pelvis or ureter. If calcium stones have been repeatedly found in one kidney, it is a good plan to get differential calcium excretion studies because occasionally the kidney in which stones reform may be found to excrete more calcium than its normal mate.

5. Blood is always drawn for serum calcium and phosphorus estimation as well as for uric acid determination. It is important to know these values. Since the determination of calcium in the laboratory is one of the more difficult tests, one must know with certainty what the normal values for each laboratory are. Otherwise, the diagnosis of hyperparathyroidism, which is essentially based on laboratory findings, is impossible. It is my custom to also collect 24-hour urine specimens for determination of calcium excretion, preferably with the patient on a normal diet, since this represents normal conditions; but if calcium excretion is considerably elevated, the patient may be given a low calcium diet for two days before the test is repeated. Determination of 24-hour excretion of uric acid may be desirable if the patient has uric acid stones, since this forms the basis for estimating the magnitude of the problem and may provide a good guide as to the effectiveness of therapy.

When these tests and examinations have been completed, one knows a great deal about the case. Negative results of tests are as valuable as positive ones. It is desirable, in the presence of hyperparathyroidism, not to operate for the removal of calculi until the parathyroid tumor is removed because of the danger that calculi will quickly recur. Cystine or uric acid calculi should not be removed until the urine has been made alkaline. It is a good plan to keep a chart of the pH of each voiding for a day or two before operation to determine how much alkalization is necessary.

CYSTOSCOPIC AND OPERATIVE REMOVAL OF CALCULI

Instrumental removal of ureteral calculi is a valuable procedure but it calls for judgment and skill and is not without hazard. In general, one may

state that only small calculi in the lower third of the ureter should be dealt with in this manner. Very jagged calculi even though small, should probably be removed by open operation rather than risk significant trauma to the ureter which may lead to stricture. A urologist's choice of methods depends somewhat on experience and skill. My own method of procedure is to operatively remove all ureteral calculi which have lodged in the upper third of the ureter, to operatively remove large (greater than 0.8 cm. in diameter) calculi lodged in the lower ureter unless they are in the intramural portion and can be caused to pass by cystoscopic ureteral meatotomy. I make one attempt to by-pass small calculi by cystoscopic manipulation and to extract them with a catheter loop or Johnson-type stone basket constructed of nylon threads. If this is not successful but the calculus can be passed by several catheters, I sometimes leave the catheters in place and occasionally get a stone by twisting and removing the catheters later. Usually, however, and particularly if there is evidence of infection above the stone, ureterolithotomy is done without delay in order to avoid the likelihood of an established pyelonephritis. Free drainage of urine is the best treatment for acute pyelonephritis. Many times significant renal damage occurs as a result of repeated attempts to remove a stone by cystoscopic manipulation.

The surgical treatment of renal calculi should have as its purpose:

1. The complete removal of all calculi without permanently damaging the parenchyma, pelvis or ureter.
2. Correction of any obstructive lesion.
3. The removal, by partial nephrectomy, of any renal unit that is irreparably damaged, not needed, and in which recurrence of stone is likely. (This may not be feasible when all functioning renal tissue is necessary to support life.)

It is probable that in the conduct of renal operations for stone, few urologists successfully accomplish these aims regularly. As a result of incomplete removal, "recurrence" of stone often takes place. Of course, the removal of all stone fragments may be technically impossible without severely damaging the kidney. The lack of recognition of mild ureteropelvic junction obstruction or replacement of the ureter or ureteropelvic junction after operation in such a way that angulation or stricture develops, often leads to persistence of infection or recurrence of stone or both. In the course of operation the ureteropelvic junction and upper ureter should be carefully visualized and obstruction by stricture or

anomalous vessel corrected. The need for surgical correction can usually be anticipated if proper pre-operative study is conducted. Proper repositioning of the ureter and pelvis is often aided by nephropexy. Occasionally, the ureter or ureteropelvic junction must be maintained in proper position by the insertion of a catheter split through the cortex or the renal pelvis.

There is usually no great technical feat connected with the removal of a calculus or calculi free in the pelvis unless the pelvis is all or nearly all intrarenal. In such cases one can make the operation relatively easy by freeing the kidney completely, thus exposing the renal vessels, and by tipping the kidney in the best way to approach the pelvis, retract the renal vessels, and expose enough of the intrarenal pelvis to incise it safely by retracting, but not incising, the renal tissue overlying the pelvis, using a small vein retractor. There is no need for haste in such cases. A little time spent in exposing all structures makes for safety, for less trauma, and for less likelihood of subsequent stricture of the ureteropelvic junction. When the pelvis is large enough to allow it, a narrow retractor may be placed in the pelvis and give good visual exposure of all the pelvis proper, even allowing one to look into the various infundibula or major calyces.

When calyceal stones are present which may not be removed by way of the pelvis it has been my practice to put a bulldog clamp on the renal artery to prevent bleeding, to locate the stone by putting a finger into the pelvis, and then incise the renal capsule directly over the stone. Using the blunt handle of the knife, it is possible to separate the elements of the renal parenchyma and approach the stone directly through the renal pyramid. Since there is no bleeding to obscure the view, one may see into the calyx, particularly if a small nasal speculum is used to retract the renal parenchyma. Using this technique one may visualize crystals or small fragments of stone on the calyceal mucosa and remove them with small wipes of gauze.

Partial staghorn calculi may often be removed by pyelotomy if one takes time to gently dilate the neck of infundibula or calyces to allow the segments of stone found in these compartments of the pelvis to slip through. Such stones may be delivered by traction and rotation of the stone while pressure is applied on the surface of the kidney. Radial incisions from the hilum through the cortex, except very short ones, are to be decried, since branches of the renal artery supplying the anterior or posterior halves of the kidney may be divided.

I believe that large staghorn calculi or large calculi which may not be delivered through the pelvis should be removed by longitudinal incision

along the coronal plain (Brödel's line) after first occluding the renal artery. The incision should be made with reference to the location of the stone. Very rarely must the entire kidney be completely sectioned. The incision should be made through the renal capsule and then the renal tissue separated, using the knife handle. By this method renal vessels can be demonstrated and ligated as one approaches the pelvis. After removal of all stone and gently wiping the calyces and pelvis free of fragments, one may release the renal artery and clamp and ligate any bleeding vessels with fine sutures. The kidney pelvis and parenchyma may then be closed without using heavy sutures which will compress and destroy renal parenchyma.

The use of nephrostomy or pyelostomy tubes should, in general, be avoided since these almost inevitably lead to the introduction of organisms all too often of the urea-splitting variety. A small vent in the pelvis with a drain placed near it is all that is necessary, and this should be removed as soon as possible.

Altogether, it would seem that a major effort should be made to improve the nicety of intrarenal operations. Much may be accomplished by a reevaluation of this subject. When fluoroscopic visualization of the calyces, pelvis and ureter becomes possible and practical, and particularly when cine-fluoroscopy is generally available, the information obtained can be expected to guide the surgical technique. Renal arteriography may be of great aid in planning the surgical removal of renal calculi.

POSTOPERATIVE CARE

After operation to remove calculi, which is often wrongly considered an end in itself, comes the problem of after-care. The immediate problems associated with this phase are rapid restoration of urine flow through the kidney for its flushing action to rid the kidney of clot, fibrin and crystalline debris. A high fluid intake is desirable unless there are limiting factors such as cardiac disease or pronounced renal impairment. A daily intake of at least 3,000 cc. of fluid, and preferably more, during the postoperative period is desirable. This accomplishes two things: It maintains a dilute urine in relation to electrolyte content and teaches the patient what an adequate fluid intake actually is in terms of fluid per day. It is not enough to urge patients to drink fluid; one must see to it that they do take adequate amounts.

In addition, one must stress around-the-clock administration of fluids for patients who are recurrent stone-formers. Adequate and appropriate antibiotic therapy is essential and should be based on sensitivity studies made on urine obtained for cul-

ture before operation or directly from the kidney pelvis at operation.

Patients with cystine or uric acid stones should be given enough 50 per cent sodium citrate solution by mouth to maintain an alkaline urine of pH 7 during the whole 24 hours. This may necessitate drinking the solution during the night. Charts should be kept of the pH of all voided urine until the proper alkalization is accomplished. The patient should be encouraged to do this at home by himself so that one may know for sure whether the urine is maintained at the proper pH.

Patients with calcium stones and triple phosphate stones should be held to a low calcium diet, and administration of fluid should be pushed hard. If a complete removal of all but crystalline fragments of stone has been accomplished, the immediate post-operative period is very important, for it appears that in many patients recurrence of stone develops very early. A good acidifying agent aside from acid-ash diet is cranberry juice. It can be used liberally in place of other fruit juices. Perhaps all stone patients should be given acetylsalicylic acid or an equivalent, although this is far from being an established important therapeutic addition. In any case, it will do no harm.

After immediate convalescence has been accomplished an intravenous pyelography should be done to see what the functional and anatomical condition of the upper urinary tract is. If there is evidence of obstruction or residual calculi, then the operation was inadequate. It is best to know this early and to plan reoperation in cases in which it is necessary.

The necessity for long-term and careful observation, in the office, of patients who are recurrent stone-formers is obvious. This consists of interval radiographic study and careful examination of the urine to make sure it is crystal-free and of the proper pH. Patients with calcium oxalate stones usually do well by simply ingesting enough fluids. On the other hand, patients with recurrent calcium phosphate or triple phosphate stones are real problems. In addition to adequate fluid intake, which may necessitate a constant daily consumption of 4,000 cc., a low calcium diet obtained by eliminating dairy products from the diet and supporting therapy to immobilize calcium or phosphorus in the bowel may be tried. This should be controlled by estimation of calcium and phosphorus urine excretion for 24-hour periods before and during administration of medication to know whether it really is effective.

To approach this problem from the phosphate side, the use of the Shorr regimen⁷ (aluminum gel preparations) in amounts of 3 or 4 ounces each day partially blocks the absorption of dietary phosphorus and may be of benefit, although it may cause troublesome constipation. Its use would seem

to be most indicated in the presence of triple phosphate stone. The elimination of part of the phosphate excreted in the urine might be expected to result in depriving calcium, magnesium and ammonium ions of phosphate radical to form insoluble triple phosphate. Recently, Henneman, Carroll and Albright⁴ reported the use of sodium phytate to decrease the urinary excretion of calcium and magnesium. Their studies indicated that 9 gm. per day of sodium phytate taken by mouth considerably decreases absorption from the bowel and accordingly urinary excretion of calcium and magnesium. One-third to one-half of the administered phytate apparently is not absorbed. It probably forms insoluble and unabsorbable complexes with calcium and magnesium. As a consequence of decreased absorption, the urinary excretion of calcium and magnesium decreases without materially altering calcium balance, suggesting that the absorption of dietary calcium is blocked but that there is no interference with the resorption of calcium secreted into the intestine through the bile and other intestinal juices. These investigators concluded that sodium phytate appears to be a safe therapeutic agent in adults and of value in the treatment of certain renal stone syndromes. It would appear that this may offer a valuable addition to the treatment of patients with recurrent calcium phosphate and triple phosphate calculi. Further investigation is certainly warranted.

To illustrate a few of the problems of diagnosis, surgical treatment and postoperative care, the following cases are presented:

CASE 1. The patient, a 42-year-old physician, was admitted to hospital November 20, 1955. He gave a history of bilateral renal colic at intervals since 1947, often associated with hematuria and the passage of multiple small calculi. None of the calculi had been analyzed but uric acid crystals had been found in the urine. An intravenous urogram, made just before admittance to hospital, showed relatively nonopaque calculi in both kidneys with mild hydronephrosis on the left. There was a history of diabetes in the family but the patient himself had never tested his urine for sugar. The blood uric acid content was said to be normal.

On physical examination he was observed to be somewhat obese. The blood pressure was 145/95 mm. of mercury. Tenderness was noted in both costovertebral angles. The hemoglobin content was 14.6 gm. per 100 cc. of blood. Leukocytes numbered 9,450 per cu. mm. The urine had a strong acid reaction, specific gravity of 1.021, 2+ albumin and 1+ sugar content, and 50 erythrocytes and 5 leukocytes per high power field. Culture of the urine showed *Staphylococcus aureus* sensitive to chloramphenicol. A nitroprusside test on the urine was negative for cystine. Serum content of calcium was 9.6 mg., of phosphorus 3.4 gm., and of uric acid



Figure 1 (Case 1).—Intravenous urogram. This demonstrates mild bilateral hydronephrosis, filling defects in renal pelves due to calculi, and good function of each kidney.

7.2 mg. per 100 cc. Calcium excretion in the urine (the patient not being on a low calcium diet) was 49 mg. in 24 hours. Phenolsulphonphthalein excretion was 35 per cent in one-half hour, 88 per cent in two hours. Fasting blood sugar at the time of admission was 163 mg. per 100 cc., but when a glucose tolerance test was done the blood sugar went from 176 mg. to 385 mg. per 100 cc. in two hours.

Results of x-ray studies were as follows: The chest was normal. A kidney-ureter-bladder film showed bilateral renal calculi filling the renal pelvis. The stones were only semi-opaque and suggested either cystine or uric acid content. Both kidneys excreted contrast substance promptly. There was bilateral hydronephrosis of about equal degree. The ureters were not dilated (Figure 1).

Removal of the calculi was planned after the urine was made alkaline by oral administration of 50 per cent sodium citrate solution. It was found it was necessary to give 8 cc. of this solution four times a day to bring the pH of the urine up to 7. No insulin was given before operation.

The left kidney was operated upon on November 25, 1955. The incision was placed over the 12th rib, which was subperiosteally resected. The kidney appeared somewhat scarred but the ureter was not dilated. The pelvis was found to be largely intrarenal and crossed by an anomalous artery and vein passing to the lower pole of the kidney. By retracting these with a small vein retractor the pelvis was satisfactorily exposed so that a longitudinal incision could be made. The stone was found to be triangu-

lar. By careful freeing, the stone was finally delivered without injury to the vessels, the pelvis or the kidney. Palpation of the interior of the pelvis then revealed many small calculi in the lower and middle calyces. Most of them were extracted by the finger, but one calculus in the lower calyx and another in the mid-calyx had to be removed through small nephrotomy incisions made directly through the renal pyramids. As almost no bleeding occurred it was not necessary to place sutures in the renal parenchyma or capsule. A nephrostomy tube (whistle-tip No. 28 Latex catheter) was placed through the lower nephrotomy into the pelvis so that urine could be obtained directly from the pelvis for microscopic study and pH determinations.

Convalescence from operation was very satisfactory. Urine from the nephrostomy tube was clear and was maintained at a pH of 6.5 to 7. On December 1, dye was injected through the nephrostomy tube and a pyelo-ureterogram was obtained which showed no residual calculi or obstruction. The nephrostomy tube was removed. Because of some wound infection, evidence of spillage of sugar in the urine, and elevated blood sugar, administration of protamine zinc insulin, 15 units each morning, was begun. The wound infection cleared and on December 12, 1955, the large triangular stone and several smaller stones were removed from the right kidney by anterior pyelotomy. Since there was no bleeding and no evidence of obstruction, the pelvis was closed except for a small vent and the wound drained with a rubber wick. Following this there was some fever for several days due to pulmonary atelectasis, which gradually cleared. Urine never drained from the incision. The rubber drain was removed on the seventh postoperative day. An intravenous urogram (Figure 2) showed good function without evidence of hydronephrosis. Upon analysis the stones were found to be pure uric acid.

The patient was sent home with prescription of fluid intake of 4,000 cc. daily, 8 cc. of 50 per cent sodium citrate solution to be taken four times a day, the last just before retiring (this having been found to maintain the urine at a pH of 7), diabetic diet without insulin, and instructions to have the urine cultured after two weeks, and to take additional antibiotics (chloramphenicol) if any infection persisted.

The patient followed all instructions completely. The latest report was on March 23, 1957, and at that time the urine was sterile. Intravenous pyelograms showed no abnormality, the urine was kept free of uric acid crystals by maintaining a fluid intake of 4,000 cc. a day and the continued use of alkalinizing agent. The patient had found that two teaspoonfuls of 50 per cent sodium citrate solution four times a day maintained the urine at a pH of 7 at all times. The blood urea nitrogen content 12 to 17 mg. per 100 cc. and to uric acid content was between 4.5 and 5.1 mg. per 100 cc. The Diabetes was controlled.

Note: This case illustrates the successful handling

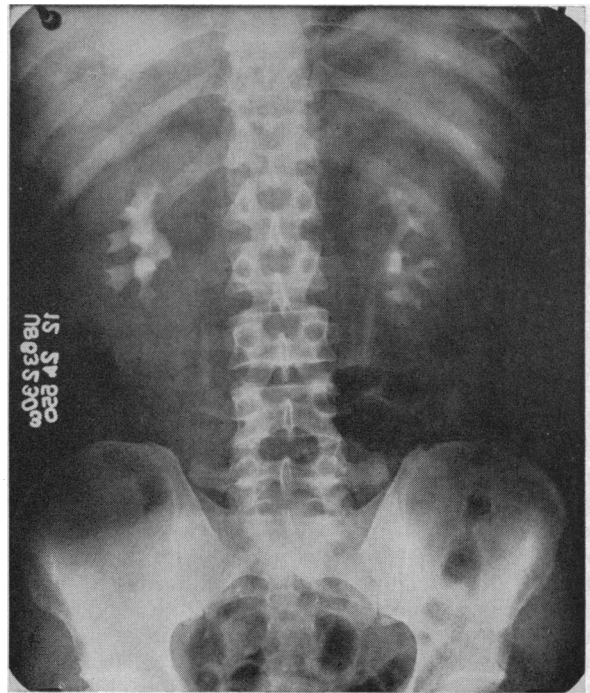


Figure 2 (Case 1).—Postoperative intravenous urogram which demonstrates almost complete resolution of bilateral hydronephrosis. No residual calculi are demonstrated.

of a complicated uric acid stone problem with complete cooperation of the patient and gives details of the examination, observation and tests, the preoperative preparation, the operative removal of calculi and the postoperative care necessary in dealing with such a case.

CASE 2. The patient was an 18-year-old college student admitted first to the Phillips House of the Massachusetts General Hospital on January 23, 1955. He gave a history of having had bladder calculi removed at the age of two and of right nephrectomy for calculus disease at the age of ten. None of the calculi were analyzed.

In August, 1954, a relatively nonopaque stone was demonstrated by x-ray in the remaining kidney. At the same time it was found that the serum uric acid was elevated to 9 mg. per 100 cc. The serum calcium and phosphorus content were within normal limits. The patient was placed on a weight reducing regimen and a low purine diet. Fluids were forced. In spite of these measures the stone increased in size and in density. It was removed in December 1954 at another hospital. Stone analysis at that time showed calcium oxalate. The patient was then admitted to the Massachusetts General Hospital for study, having made a good convalescence from the operation.

Except for multiple surgical scars and mild obesity, no abnormalities were noted on physical examination. The blood pressure was 130/90 mm. of mercury. The urine gave an acid reaction, the specific gravity was 1.022, the albumin reaction 1+.

It contained cystine crystals. *Staphylococcus albus* reasonably sensitive to chloramphenicol grew on a culture of urine. The serum uric acid content was 6.8 mg. per 100 cc., calcium 9.2 mg. per 100 cc., and phosphorus 3.7 mg. per 100 cc. Urine calcium excretion in 24 hours was 104 mg. Phenolsulphonphthalein excretion was 30 per cent in one-half hour and 80 per cent in two hours. An intravenous urogram showed no calculi. The left kidney shadow appeared somewhat enlarged. The kidney excreted dye promptly and in good concentration. The calyces appeared somewhat blunted and the lower infundibulum slightly widened. There was no evidence of ureteral obstruction, however (Figure 3).

Neither the mother nor the father of the patient had cystinuria. It was obvious that cystinuria and formation of cystine stones was probably the primary problem in this case and that the calcium oxalate in previous stones was owing to the secondary deposition of calcium oxalate on a cystine nucleus. The patient was discharged with instructions to take three to four thousand cubic centimeters of fluid daily, to omit dairy products from his diet and to take 12 cc. of 50 per cent sodium citrate solution four times daily. He was taught how to determine the urinary pH and specific gravity and how to examine the urinary sediment for crystals. To do this, he bought a microscope. He was to keep charts so that we could study the effectiveness of the therapy.

All went well for a time. The urine remained at a pH of approximately 7.5. Fluid intake approached 4 liters daily. X-ray films showed no recurrence of stone until January of 1956 when a kidney-ureter-bladder study demonstrated a calculus again in the kidney. It seemed that the precipitating factor was an automobile trip to Mexico in the fall of 1955, during which the patient strayed from the prescribed regimen. As a consequence he was readmitted to the Massachusetts General Hospital on February 20, 1956.

The blood pressure at this time was 100/70 mm. of mercury. An intravenous urogram showed a clearly defined calcification, consisting of a partial staghorn stone filling the lower calyces and the lower infundibulum of the remaining kidney (Figure 4). Renal function was prompt and, except for distortion of the lower calyces by calculus, the pelvis and the calyces appeared essentially normal. Laboratory studies showed serum uric acid of 7.2 mg. per 100 cc., calcium 104 mg. per 100 cc. and phosphorus 4.1 mg. per 100 cc. Urinary calcium excretion in 24 hours was 61.2 mg. on one occasion and 127.6 on another. The urine was again positive for cystine (nitroprusside test).

It was felt that the stone should be removed before it became larger and more of a surgical problem. Therefore on February 27 the left kidney was explored and the stone removed through a pyelotomy and a small nephrolithotomy. It was found that there were two types of stones, an irregular rough stone which was found to consist of calcium phosphate and cystine, and small spherical stones

consisting of pure cystine. At operation a nephrostomy tube was left in the pelvis through the lower calyx for four days. A renal biopsy showed a normal kidney. Convalescence was entirely satisfactory.



Figure 3 (Case 2).—Intravenous urogram. There is good renal function with slight dilatation of all calyces.

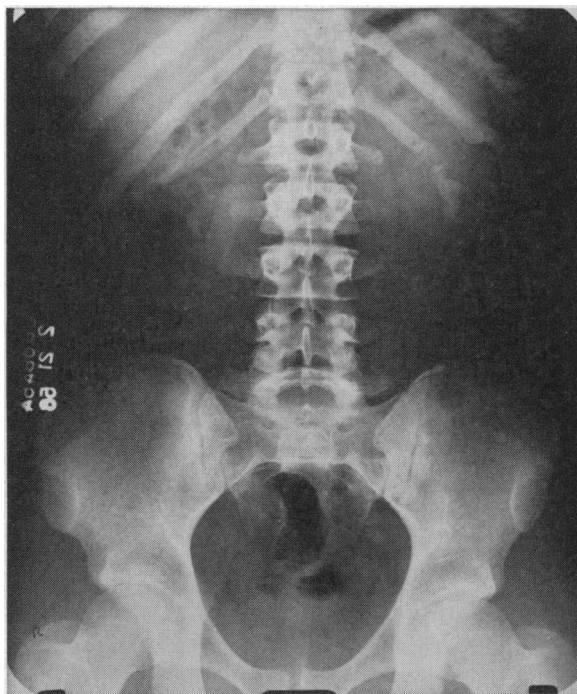


Figure 4 (Case 2).—Kidney-ureter-bladder x-ray film. The calculus filling the lower calyces and infundibulum is clearly shown.

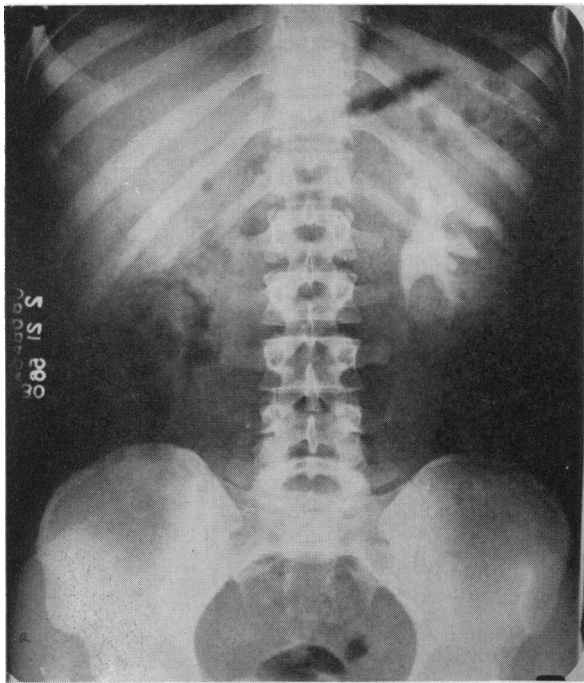


Figure 5 (Case 2).—Postoperative intravenous urogram. Although the dye obscures them here, two small residual calculi were noted on the kidney-ureter-bladder film.

Urine obtained directly from the left kidney pelvis at operation was sterile. Phenolsulphonphthalein excretion was 70 per cent in two hours. A postoperative intravenous urogram (Figure 5) showed two probable small residual or recurrent nonopaque calculi in the lower calyces of the kidney. There was no change in the calyceal pattern but there was a suggestion of narrowing of the uretero-pelvic junction, thought probably due to postoperative scar. It was hoped that this would resolve.

It seemed quite certain at this point that cystine calculi represented the primary problem, which was compounded by the deposition of calcium phosphate due to the maintenance of an alkaline urine. Study of the urine sediment showed that cystine crystals appeared when the pH was below 6. Calcium phosphate crystals became apparent above pH of 7. The problem therefore was a difficult one. It was finally decided to try to maintain a mildly alkaline urine with low specific gravity by a high fluid intake and a moderate dose of 50 per cent sodium citrate daily. In addition, acetylsalicylic acid was given in the hope that the drug might favorably affect the solubility of calcium phosphate in the urine.

The patient was readmitted for study on December 27, 1956. He had no complaints of any sort. Cystoscopy and calibration of the left ureter were carried out. The ureter took a No. 10 bulb easily, but 10 cc. of urine could be aspirated from the kidney pelvis, indicating inadequate drainage. A kidney-ureter-bladder x-ray film and air and conventional pyelograms were made. The small stones that had been visualized ten months before were



Figure 6 (Case 2).—Retrograde pyelogram made 10 months after operation. Subsequent pyelographic studies in July 1957, 16 months after operation, showed no calculi and similar pyelographic picture.

less clearly visualized, but there seemed to be still one or more small stones in the lowest calyx. Moderate dilatation of the calyces and pelvis was still present (Figure 6). The patient was discharged with instruction to continue the regimen as before, and he continued well. Intravenous urograms made in July, 1957, showed no calculi.

Note: It may be desirable in this case to resect the lower calyx as a stone-bearing area, since calculi have not demonstrably formed elsewhere in the kidney. It would seem possible that the two operations on the lower calyces damaged the calyceal musculature so that peristaltic activity of these lower calyces is not normal. In any case, this illustrates one of the more difficult stone problems—primary cystine stones associated with calcium oxalate or calcium phosphate stones probably due to alkalization of the urine with decreased solubility of calcium and a tendency to precipitate on cystine nuclei. A regimen of alkalization and high fluid intake, to be fairly effective must be rigidly adhered to, regardless of other considerations. It is fortunate that the patient here reported upon is intelligent, willing and co-operative. The complexity of the problem in handling such cases is well illustrated. Fortunately, infection was of no major concern in this case.

CASE 3. A 60-year-old woman was admitted to the Phillips House of the Massachusetts General Hospital on October 30, 1950. At that time she gave a history of bilateral flank pain since the age of 5

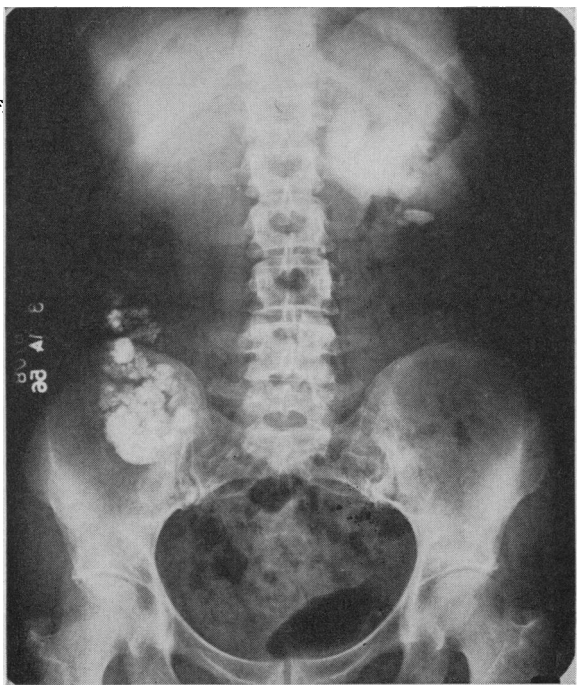


Figure 7 (Case 3).—Kidney-ureter-bladder x-ray film. This demonstrates large and smaller calculi filling the left renal pelvis, and multiple small calculi in a decidedly hydronephrotic right kidney.



Figure 8 (Case 3).—Intravenous urogram delineates normal upper left calyces, dilated and distorted lower left calyces. There is almost no dye excreted by the right kidney.

years. The nature of her trouble was not discovered during childhood. In 1934 she passed a calculus. More recently a kidney-ureter-bladder x-ray film was made which showed calcified shadows in the region of the right kidney. Pyuria was also demonstrated. An examination in 1950 revealed exophthalmos, a symmetrically enlarged thyroid gland, blood pressure of 180/90 mm. of mercury, evidence of arteriosclerosis and tenderness in the left flank. There were many leukocytes in the urine. Culture of a specimen of urine grew *E. coli*. The nonprotein nitrogen content of the blood was 26 mg. per 100 cc. The serum calcium was 9.6 mg. per 100 cc. and the phosphorus content 3.6 mg. per 100 cc. Cystoscopy was done and a catheter was passed to the left pelvis, from which 180 cc. of clear urine was drained. On the right a catheter would not enter the pelvis. Retrograde pyelograms were poor but did demonstrate obstructions in both uretero-pelvic regions. It seemed likely that numerous calcified shadows in the right abdomen were calculi in a decidedly hydronephrotic right kidney. A Finney-type pyeloplasty was done on the left side on November 29, 1950. Satisfactory convalescence followed.

On February 15, 1953, the patient was readmitted with myocardial infarction, from which she made a slow but satisfactory recovery. She was then well until March 9, 1956, when she began to have severe pain in the left flank and oliguria. This was followed some hours later by copious output of urine containing much gravel. X-ray studies were obtained which showed a large staghorn calculus occupying the left kidney pelvis and calyces (Figure 7). The

stones in the right kidney area were as previously noted. An intravenous pyelogram showed fairly prompt excretion on the left side, outlining dilated calyces (Figure 8). The uretero-pelvic junction was not visualized. At this point I was asked to see the patient. Cystoscopy was carried out and the bladder was observed to be inflamed. The left ureter was catheterized but the catheter would not pass through into the kidney pelvis. A retrograde pyelogram (Figure 9) demonstrated narrowing of the left uretero-pelvic junction. Laboratory studies showed pronounced pyuria. The urine culture showed non-hemolytic streptococci and *B. coli* sensitive to chloramphenicol, terramycin, aureomycin and tetracycline. The nonprotein-nitrogen content was 24 mg. per 100 cc. of serum. Serum uric acid was 5.9 mg., calcium 9 mg. and phosphorus 3.2 mg. per 100 cc. Urinary calcium excretion in 24 hours was 364 mg., which perhaps was due to the abundance of calcium phosphate shed from the stones into the urine.

It was obvious that, since the right kidney was asymptomatic and almost functionless, operation on the left to remove the calculi and correct the uretero-pelvic obstruction was obligatory. This was carried out on April 11, 1956. At operation the kidney appeared scarred but the cortex was not greatly thinned. An anomalous artery and vein were found crossing the uretero-pelvic junction embedded in scar tissue. The uretero-pelvic junction itself was considerably narrowed. It was obvious that the anomalous vessels had to be divided in order to carry out any type of operation. The stones were

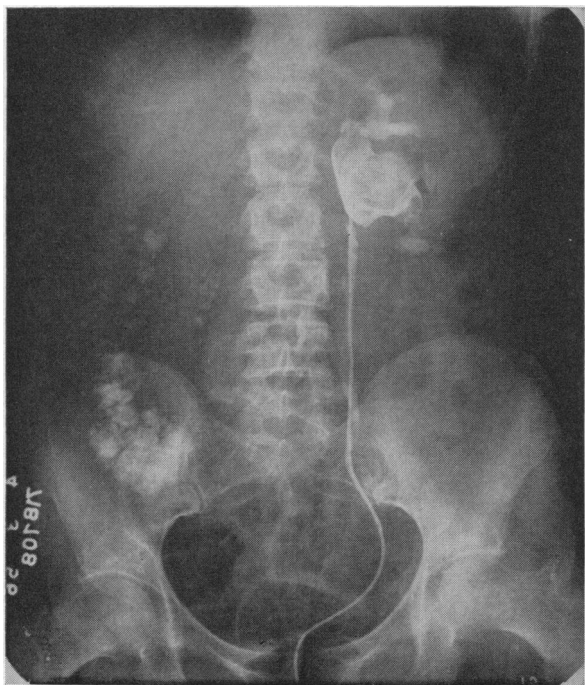


Figure 9 (Case 3).—A left retrograde pyelogram which demonstrates stricture at the left ureteropelvic junction and filling of pelvis and calyces about calculi.

removed through an anterior pyelotomy and two small nephrotomy incisions. The lower part of the kidney which had been rendered ischemic by division of the anomalous vessels was resected. Correction of the uretero-pelvic junction obstruction was carried out by resecting the area of stricture, excising a portion of the redundant pelvis, and reimplanting the ureter into the pelvis in an oblique fashion—in other words, using the principle of elliptical anastomosis. A splinting latex rubber ureterostomy catheter was placed through the lower infundibulum and down the ureter. The pelvis was drained by a whistle-tip nephrostomy tube passed alongside the ureteral splint.

Convalescence was very satisfactory. During the first 24 hours, 1,500 cc. of urine was collected from the left nephrostomy tube. It was found that when fluid was injected into the nephrostomy tube, it passed quickly to the bladder. The kidney pelvis was irrigated daily, using a continuous drip of solution G* through the nephrostomy tube until April 21, when the tubes were both removed. On this date a kidney-ureter-bladder x-ray film and a pyelogram were obtained by injecting contrast medium through the nephrostomy tube. This revealed no evidence of residual calculi. The pelvis was small and funneled and it drained quickly via the ureter. During this time a daily output of 2,000 cc. was maintained. The patient was given supplementary therapy of acid-ash, low calcium diet and cranberry juice to help

*Magnesium oxide 15.2 gm., anhydrous sodium carbonate 17.6 gm., citric acid 129.2 gm., distilled water to make 4,000 cc.

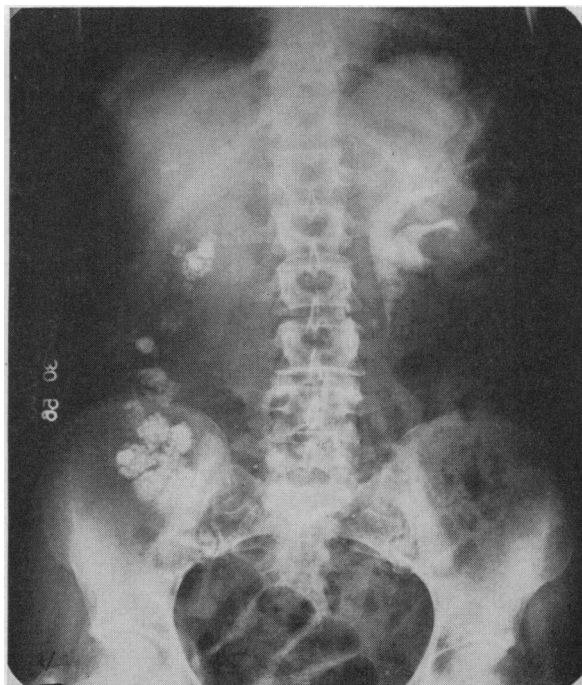


Figure 10 (Case 3).—Intravenous urogram made before discharge of patient, demonstrating good function, diminished hydronephrosis and funneled uretero-pelvic junction.

acidify the urine, Basaljel (basic aluminum carbonate gel), 30 cc. four times a day, and appropriate antibiotics. Urinary pH charts showed that the urine was maintained at a pH of between 5 and 6. Urinary excretion of calcium before the patient was discharged was 65 mg. and of phosphorus 230 mg. in 24 hours.

An intravenous urogram (Figure 10) showed very satisfactory function of the left kidney with absence of the stones previously noted, a decrease in the degree of hydronephrosis and prompt emptying. The right kidney remained unchanged. Intravenous urograms were repeated in July, 1956, and in March, 1957, and showed no recurrence of stones in the left kidney or evidence of uretero-pelvic junction obstruction (Figures 11 and 12).

The patient was discharged with prescription of a low calcium, acid-ash diet supplemented by cranberry juice and 3,000 cc. of water daily. Three grams of acetylsalicylic acid and 4 ounces of Basaljel a day were also advised. She followed that regimen until the time of this report, except the Basaljel was discontinued after six months because of pronounced constipation. The urine remained infected but specimens contained only a few leukocytes. The patient was asymptomatic. The urinary pH stayed between 5 and 6.

Note: This case illustrates stone formation in relation to obstruction and infection, and shows that careful removal of calculi together with reconstructive operation and a good postoperative pro-

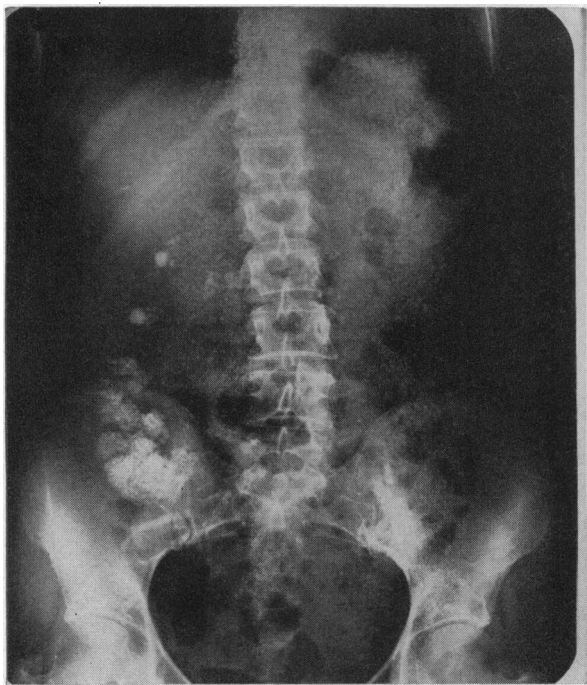


Figure 11 (Case 3).—Kidney-ureter-bladder x-ray film taken after one year. No recurrence of calculi is noted.

gram of free drainage, fluids, diet and medication have much to offer for cases of this type. It was most fortunate that the patient did not have an active urea-splitting infection to combat as well.

CASE 4. A 69-year-old woman was admitted to the Massachusetts General Hospital on November 11, 1956. The history was one of repeated episodes of urinary lithiasis beginning 20 years before when a stone had been removed by cystoscopic manipulation. Eleven years before, the right kidney had been removed because of calculus disease. An impacted left ureteral stone was removed by ureterolithotomy in August, 1956. Up to that time no stone analyses or serum calcium or phosphorus studies had been carried out. During the convalescence from the ureterolithotomy, stones were noted to have recurred in the left kidney. Serum calcium was found to be 12 mg. per cent and the patient was referred to me for study. She had never had a dietary or medical regimen prescribed.

On physical examination the patient appeared to be healthy. The blood pressure was 188/100 mm. of mercury. The thyroid was normal to palpation. Abdominal scars were noted and the left kidney was somewhat tender.

The urine showed a specific gravity of 1.011. It was neutral with 4+ albumin, contained no sugar, but had many leukocytes and erythrocytes. Coliform bacilli not sensitive to any drug except neomycin grew on a culture of urine. Nonprotein nitrogen was 25 mg. per 100 cc., uric acid 6.6 mg., fasting blood sugar 99 mg. and total protein 7 gm. per 100 cc. (albumin 4.2 gm., albumen 2.8 gm.).

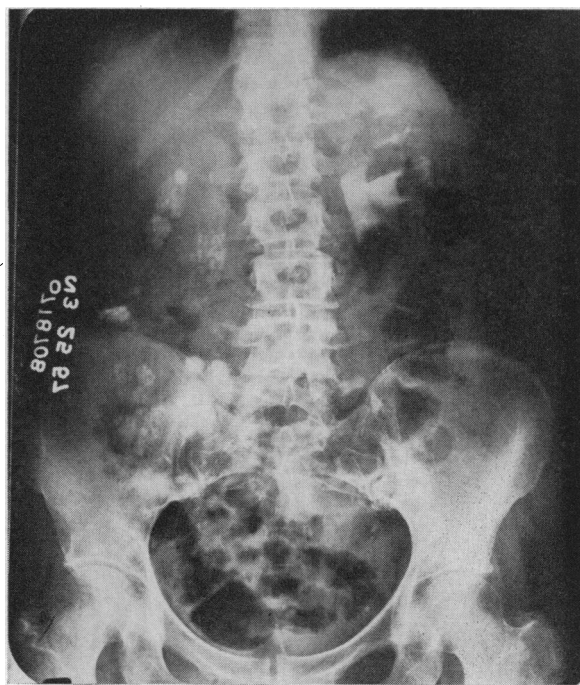


Figure 12 (Case 3).—Intravenous urogram after one year, showing further diminution of left hydronephrosis.

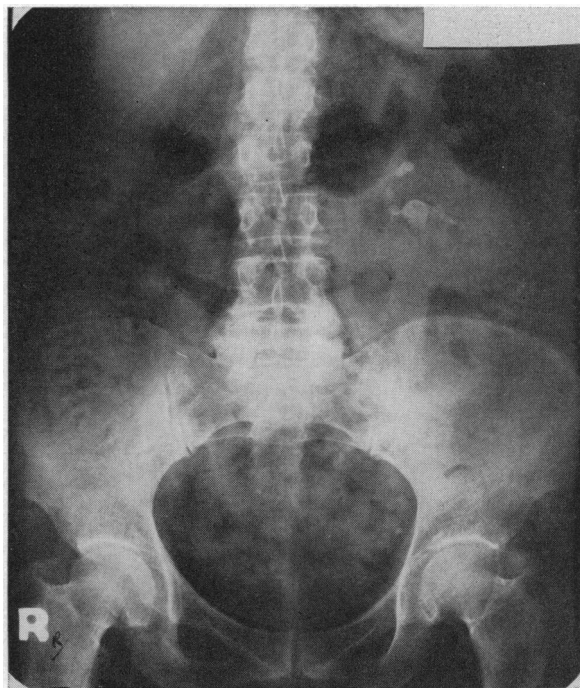


Figure 13 (Case 4).—Kidney-ureter-bladder x-ray film showing recurrent calculi in remaining kidney.

Phenolsulphonphthalein excretion was 15 per cent in a half hour and 43 per cent in two hours. Serum calcium was 12.6 mg. per 100 cc. on one occasion and 12.2 mg. on another. The phosphorus content was 2.2 mg. and 2.8 mg. per 100 cc. Urinary calcium excretion was 197 and 273 mg. in 24 hours.

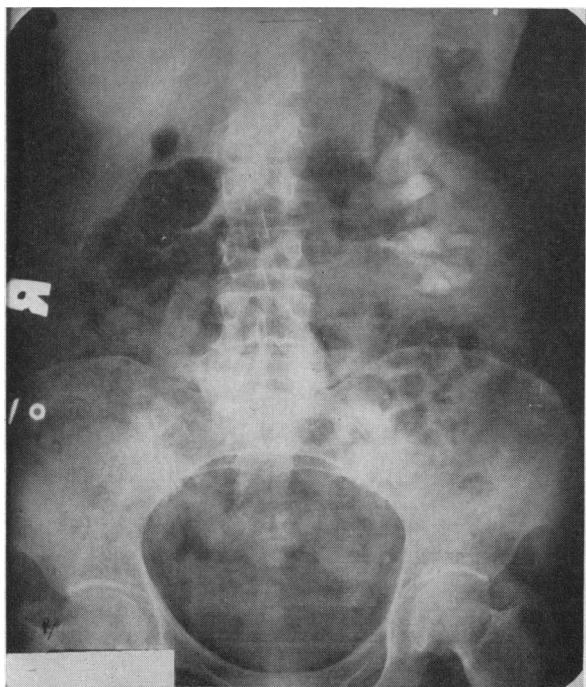


Figure 14 (Case 4).—Intravenous urogram. Obstruction of infundibula by calculi has caused moderate calyectasis.

X-ray films of the chest and bones showed no abnormality. Barium swallow films showed indentation on the right side of the esophagus compatible with parathyroid adenoma. A kidney-ureter-bladder roentgenogram and intravenous urogram which the patient had had in an outside hospital (Figures 13 and 14) showed multiple calculi filling the lower half of a bifid left kidney pelvis with considerable hydronephrosis of the upper half. Seven to ten stones were visualized, the largest being about 2 cm. in diameter. A diagnosis (presumptive) of hyperparathyroidism, renal calculi and chronic pyelonephritis of the remaining kidney was made. The surgical consultant agreed. It was decided to explore for a parathyroid adenoma and subsequently to operate to remove stones from the left kidney. Exploration was carried out December 1, 1956, and an adenoma (pathologically proved) was found within the right lobe of the thyroid. Convalescence was satisfactory. Serum calcium was 7.6 mg. per 100 cc. immediately after operation and later was 8.9 mg., 8 mg. and 9.4 mg. per 100 cc., the last on December 18, 1956. Serum phosphorus on these occasions was 3.6, 3.2, 3.1, 4.2 and 6 mg. per 100 cc. No supplementary calcium was given.

It was felt by the medical consultant that the urinary calculi remaining in the left kidney might disintegrate or pass, but it seemed to me, in view of the solitary kidney, and significant infection, if such occurred, it might be extremely hazardous since it was more than likely that stone fragments would obstruct, necessitating emergency procedures with the likelihood of more renal damage. Therefore, on December 11, 1956, the left kidney was explored.

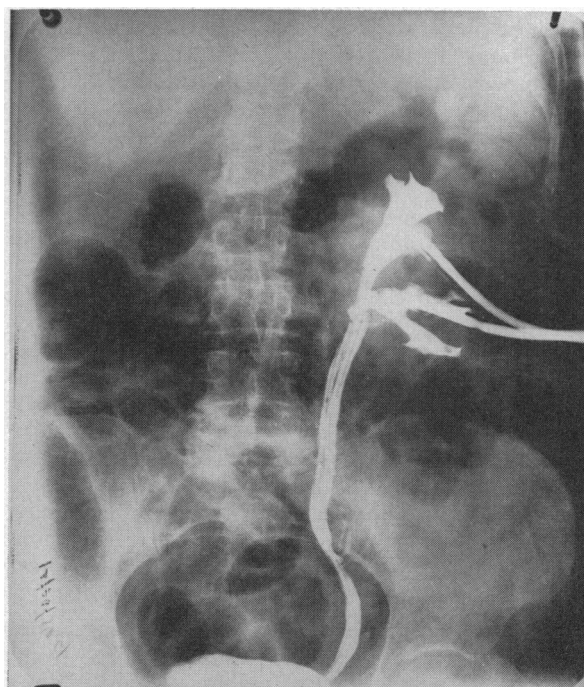


Figure 15 (Case 4).—Pyelogram obtained by injecting nephrostomy tubes illustrates method of splinting uretero-pelvic junction and draining kidney.



Figure 16 (Case 4).—Intravenous urogram before discharge of patient. This shows prompt function and resolution of hydronephrosis.

It was found that the extrarenal pelvis was very tiny and divided just above the uretero-pelvic junction into upper and lower infundibula which were moderately strictured. The stones were removed by pyelotomy, except for several small calculi in the

lower calyces which were removed through a small nephrotomy incision in the lower pole. After all calculi were delivered it was found that the uretero-pelvic junction had been traumatized badly. Therefore two ureteral splinting catheters as well as two nephrostomy tubes were introduced to maintain drainage from both halves of the kidney in the immediate postoperative period. One splint-catheter and one nephrostomy tube were introduced through the nephrotomy incision which had been made previously to remove the calculi, and the other ureterostomy tube and nephrostomy tube were introduced through one of the upper calyces to provide drainage from the upper half of the kidney. The patient tolerated the operation well in spite of the fact that the calyces behind the stones were filled with pus. A pyeloureterogram obtained by injecting contrast medium into the nephrostomy tubes several days later (Figure 15) illustrates the method of drainage. All tubes were removed 16 days after operation when the pelvis was filled with dye and no leakage of it occurred at the uretero-pelvic junction.

An intravenous urogram (Figure 16) was made on December 31, 1956, just before discharge from the hospital, which showed moderately good function and reasonably free drainage. No calculi were visualized. During the postoperative period no special therapeutic measures were used other than the maintenance of a high fluid intake and the use of an acid-ash diet with cranberry juice to help maintain an acid urine. Last reports from the physician who had referred her were that patient was free from urinary complaints. There were no pus cells in the urine and the pH was maintained at from 5.5 to 6.

Intravenous urograms showed no calculi or obstruction at the uretero-pelvic junction.

Stone analysis showed ammonium and calcium phosphate and oxalate.

Note: This case illustrates the not uncommon history of patients with renal calculi due to parathyroid adenoma. Repeated colic, often several operations and frequently the loss of one kidney may occur before the diagnosis is made—which suggests that, in the presence of calcium stones, serum calcium and phosphorus studies should always be made.

Massachusetts General Hospital, Boston 14.

REFERENCES

1. Baker, R., and Connelly, J. P.: Bilateral and recurrent renal calculi, *J.A.M.A.*, 160:1106-1110, March 31, 1956.
2. Boyce, W. H., Garvey, F. K., and Norfleet, C. M.: Ion-binding properties of electrophoretically homogeneous mucoproteins of urine in normal subjects and in patients with renal calculus disease, *J. Urol.*, 72:1019-1031, Dec. 1954.
3. Idem: The metal chelate compounds of urine, *Am. J. Med.*, 19:87-95, July 1955.
4. Henneman, P. H., Carroll, E. L., and Albright, F.: The suppression of urinary calcium and magnesium by oral sodium phytate; a preliminary report, *Ann. of N. Y. Academy of Sciences*, 64:343-350, Aug. 17, 1956.
5. Prien, E. L., and Walker, B. S.: Studies in urolithiasis. IV. Urinary glucuronisides and calcium phosphate, *J. Urol.*, 74:440-446, Oct. 1955.
6. Idem: Salicylamide and acetylsalicylic acid in recurrent urolithiasis, *J.A.M.A.*, 160:355-360, Feb. 4, 1956.
7. Shorr, E., and Carter, A. C.: Aluminum gels in the management of renal phosphatic calculi, *J.A.M.A.*, 144:1549-1556, Dec. 30, 1950.
8. Snapper, I., Bendien, W. M., and Polak, A.: Observations on the formation and prevention of calculi, *Brit. J. Urol.*, 8:337-345, Dec. 1936.

Social Security Footnotes

To SUPPORT socialistic practices in regard to retirement funds requires that, for the sake of consistency, socialized medicine also be supported. If one believes that the federal government should tax everyone to provide an income for each upon retirement or disability, one must also believe that the same government should, with equal propriety, tax everyone to provide medical care for all!

—From the Department of Public Relations, American Medical Association